Mycopath (2017) 15(2): 87-93 **Research Article**

Possible antifungal and antibacterial constituents in inflorescence extract of *Carthamus oxycantha*

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Abstract

The objective of the present study was to identify possible antifungal and antibacterial compounds in methanolic extract of inflorescence of *Carthamus oxycantha*, a weed of family Asteraceae. Methanolic extract was obtained by soaking 5 g of dried and powdered inflorescence in 100 mL methanol for 14 days. Analysis of the methanolic leaf extract revealed the presence of 103 organic compounds. Most abundant compounds were Phosphoric acid, bis(trimethylsilyl)monomethyl ester (7.41%), D-Ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)- (7.19%), Benzoic acid, 4-hydroxy-3-methoxy-, methyl ester (6.27%), 13-Retinoic acid, (Z)-, TMS derivative (5.18%), 9-Octadecenoic acid, (E)-, TMS derivative (4.92%), Bis(2-ethylhexyl) phthalate (4.61%), and 5-Amino-8-hydroxyquinoline, N,O-bis(trimethylsilyl)- (4.14%). Out of 103 compounds, 4 compounds were found having antibacterial and/or antifungal properties. These compounds were 9-Octadecenoic acid, (E)-, TMS derivative (**5**); Bis(2-ethylhexyl) phthalate (**6**); 2,4-Thiazolidinedione (**19**); γ-Sitosterol (**32**); 4-Hydroxybutanoic acid, 2TMS derivative (**40**). This study concludes that methanolic inflorescence extract is a rich source of antimicrobial agents.
Keywords: Antibacterial, Antifungal, Asteraceae, *Carthamus oxycantha*, GC-MS, Inflorescence extract.

Introduction

Asteraceae is a family of enormous flowering plants which under 13 subfamilies and 1,911 genera, comprises 32,913 species (Kadereit and Jeffrey, 2007). Recent phylogenetic analysis revealed that it is also well known for its diversity as it includes different types of plants (Panero *et al.*, 2014; Katinas *et al.*, 2016). The most of species of this family have been reported for their bioactivity against microbes and are widely applicable in drugs (Bessada *et al.*, 2015). Similarly, the highest flavonoid and phenolic compounds in this family enhance its medicinal importance (Koc *et al.*, 2015). The plant extracts of Asteraceae family are being reported as antimicrobial agents against the disease (Filho *et al.*, 2008).

Carthamus oxycantha (wild safflower) is a weed belonging to the Asteraceae family. It is widely found on barren lands, along the water channels, and the banks of cropping areas. In Pakistan, this medicinal plant is also found along the Motorway linking capital Islamabad with Lahore (Ahmad, 2007). Its seeds and leaves are being used for treatment of Jaundice and ulcer (Mahmood *et al.*, 2011; Marwat and Khan, 2012). Pandey and Singh (2017) enlisted more medicinal uses of this weed in India including itching, bronchitis and for improving blood circulation. The extract of *C. oxycantha* with different solvents has been proved effective against bacteria (Raza *et al.*, 2015). In the current research work, GC-MS analysis of methanolic extract of inflorescence of *C. oxycantha* was carried out to enlist various compounds present in the extract, followed by literature survey to identify antibacterial and antifungal compounds.

Materials and Methods

Preparation of methanolic extract

C. oxycantha was collected from a barren land in Lahore. Inflorescence was separated, dried and crushed to change it into powder form. The weighed amount of powdered (5 g) was soaked in 100 mL methanol for 14 days. After the completion of said period, the material was passed from a muslin cloth and the liquid was passed through a filter paper. The extract was used for GC-MS analysis.

GC-MS Analysis

A volume of 0.3 mL of methanolic inflorescence extract was transferred to GC vials and dried overnight in a SpeedVac system. The extract was subjected to methoximation with methoxyamine hydrochloride (Sigma) at 30 °C for 90 min. The sample was silylated with BSTFA/TCMS (Sigma) at 60 °C for 30 min, and then subjected to gas chromatography-mass spectrometry (GC-MS) on an Agilent 7890C gas chromatograph in tandem with a 5975C MSD. The GC oven program began with at 80 °C and was held for 1.0 minute ramped at 15 °C min^{-1} to 320 °C which was held for 3 min. The mass range was set from 40–800 m/z. The separation column was an HP5MSI (30 m long, 0.250 mm ID, 0.25 μm film thickness). The mass spectrometer operated under standard conditions with a 230 °C ion source. Identification and quantification was conducted using AMDIS with a manually curated retention indexed GC-MS library with additional identification performed using the NIST17 and Wiley 11 GC-MS spectral libraries.

Results and Discussion

Methanolic extract contained 103 compounds which are presented in Table 1 along with their molecular masses, formulae, retention time and peak area (%). Among these, predominant compounds were Phosphoric acid, bis(trimethylsilyl) monomethyl ester (7.41%); D-Ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)- (7.19%); Benzoic acid, 4-hydroxy-3-methoxy-, methyl ester (6.27%); 13-Retinoic acid, (Z)-, TMS derivative (5.18%); 9-Octadecenoic acid, (E)-, TMS derivative (4.92%); Bis(2-ethylhexyl) phthalate (4.61%); and 5-Amino-8-hydroxyquinoline, N,O-bis(trimethylsilyl)- (4.14%). Moderately abundant compounds included 2-methylidene-6,10,14-trimethylpen2-methylidene-6,10,14-trimethylpentadecanoic acid silylated (3.69%); 1-(Palmitoyloxy)-3-((trimethylsilyl)oxy) propan-2-yl (Z)-hexadec-9-enoate (3.06%); 2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)- (2.48%); l-Isoleucine, N-trifluoroacetyl- (2.46%); γ-Tocopherol, TMS derivative (2.16%); Cetene (2.12%); Dehydroabietic acid, TMS derivative (2.03%); and Decanedioic acid, bis(2-ethylhexyl) ester (2.02%). Nine compounds namely Benzoic acid, 3-[(trimethylsilyl)oxy]-, trimethylsilyl ester (1.64%); D-Glucose, 2,3,4,5,6-pentakis-O-(trimethylsilyl)-, O-methyloxime (1.51%); Pentanedioic acid, 2TMS derivative (1.44%); 2,4-Thiazolidinedione (1.36%); Glycerol, 1,2-di(TMS)- (1.26%); Benzene, [(3-butynyloxy)methyl]- (1.17%); Undecanedioic acid, 2TMS derivative (1.12%); 2-Aminoethanol, N-acetyl-, O-TMS (1.11%); and Benzoic acid, 3,4,5-tris(trimethylsiloxy)-, trimethylsilyl ester (1.04%) were less abundant. Remaining 79 compounds were least abundant with peak areas 0.95% to 0.05%.

Among 103 compounds identified in inflorescence extract of *C. oxycantha*, 4 compounds were found in literature having antifungal and/or antibacterial properties (Table 2, Fig. 1). 9-Octadecenoic acid, (E)-, TMS derivative (**5**) was identified as an abundant compound in the present study. It is a derivative of oleic acid with replacement of –H of –COOH with $–Si(CH3)_3$. Oleic acid identified from neem has been known to possess antibacterial activity against a number of pathogenic bacteria namely *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* sp. (Zhong-hui *et al.*, 2010). Bis(2-ethylhexyl) phthalate (**6**) a predominant compound in this study with 4.61% peak area. The compound is a well known plasticizer but has been reported in many plant species including *Aloe vera*, *Alchornea cordifolia* and *Euphorbia seguieriana* (Toth-Soma *et al.*, 1993; Lee *et al.*, 2000; Mavar-Manga *et al.*, 2008). This compound has also been isolated from *Calotropis gigantean* with antibacterial activity against various species of Gram negative namely *Shigella sonnei*, *S. shiga* and *Escherchia coli*, and Gram positive bacteria namely *Sarcina lutea* and *Staphylococcus aureus* (Habib and Karim, 2009). Less abundant compound 2,4-Thiazolidinedione (**19**) is a heterocyclic compound with important pharmaceutical applications. Various derivatives of this compound are known to possess a number of biological properties including antifungal and antibacterial activities against *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, *C. parapsilosis*, *C. krusei* and *C. glabrata* (Tuncbilek and Altanlar, 2006; Bozdag-Dundar *et al.*, 2007). Ethanolic extract exhibited Frankenia hirsuta exhibited potent antimicrobial activity against a fungus *Candida* sp. and many bacteria. γ-Sitosterol (32) was found the 2^{nd} most abundant compound in the extract and was probably the cause of antimicrobial activity (Canli *et al.*, 2017). This compound has also been identified from Sydney rock oyster *Saccostrea glomerata* and showed antimicrobial activity against pathogenic bacteria and fungi (Karthikeyan *et al.*, 2014). This study concludes that inflorescence extract of *C. oxycantha* contains some potent antimicrobial compounds. Further studies are needed to isolate and purify these phytochemicals.

Table 1: Compounds identified from methanolic inflorescence extract of *Carthamus oxycantha* through GC-MS analysis.

No.	Names of compounds	Formula	Weight	Retention time (min)	Peak area (%)
1	Phosphoric acid, bis(trimethylsilyl)monomethyl ester	$C_7H_{21}O_4PSi_2$	256.385	5.42	7.41
2	D-Ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)-	$C_{15}H_{36}O_5SSi_3$	412.763	8.41	7.19
3	Benzoic acid, 4-hydroxy-3-methoxy-, methyl ester	$C_{10}H_{12}O_4$	196.202	8.47	6.27
4	13-Retinoic acid, (Z)-, TMS derivative	$C_{23}H_{36}O_2Si$	372.624	15.26	5.18

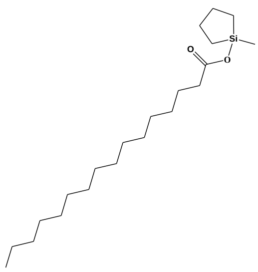
5	9-Octadecenoic acid, (E)-, TMS derivative	$C_{21}H_{42}O_2Si$	354.65	13.26	4.92
6	Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	390.564	15.11	4.61
7	5-Amino-8-hydroxyquinoline, N,O-bis(trimethylsilyl)-	$C_{15}H_{24}N_2OSi_2$	304.54	16.35	4.14
8	2-methylidene-6,10,14-trimethylpen2-methylidene-6,10,14-trimethylpentadecanoic acid silylated	$C_{22}H_{44}O_2Si$	368.677	11.72	3.69
9	1-(Palmitoyloxy)-3-((trimethylsilyl)oxy)propan-2-yl (Z)-hexadec-9-enoate	$C_{38}H_{74}O_5Si$	639.09	19.233	3.06
10	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	$C_{14}H_{20}O_2$	220.312	8.08	2.48
11	l-Isoleucine, N-trifluoroacetyl-	$C_8H_{12}F_3NO_3$	227.183	6.48	2.46
12	.gamma.-Tocopherol, TMS derivative	$C_{31}H_{56}O_2Si$	488.872	17.32	2.16
13	Cetene	$C_{16}H_{32}$	224.432	8.97	2.12
14	Dehydroabietic acid, TMS derivative	$C_{23}H_{36}O_2Si$	372.624	14.37	2.03
15	Decanedioic acid, bis(2-ethylhexyl) ester	$C_{26}H_{50}O_4$	426.682	16.35	2.02
16	Benzoic acid, 3-[(trimethylsilyl)oxy]-, trimethylsilyl ester	$C_{13}H_{22}O_3Si_2$	282.486	8.82	1.64
17	D-Glucose, 2,3,4,5,6-pentakis-O-(trimethylsilyl)-, O-methyloxime	$C_{22}H_{55}NO_6Si_5$	570.108	11.42	1.51
18	Pentanedioic acid, 2TMS derivative	$C_{11}H_{24}O_4Si_2$	276.479	7.44	1.44
19	2,4-Thiazolidinedione	$C_3H_3NO_2S$	117.122	5.06	1.36
20	Glycerol, 1,2-di(TMS)-	$C_9H_{24}O_3Si_2$	236.458	5.55	1.26
21	Benzene, [(3-butynyloxy)methyl]-	$C_{11}H_{12}O$	160.216	17.08	1.17
22	Undecanedioic acid, 2TMS derivative	$C_{17}H_{36}O_4Si_2$	360.641	11.85	1.12
23	2-Aminoethanol, N-acetyl-, O-TMS	$C_7H_{17}NO_2Si$	175.303	5.64	1.11
24	Benzoic acid, 3,4,5-tris(trimethylsiloxy)-, trimethylsilyl ester	$C_{19}H_{38}O_5Si_4$	458.848	11.73	1.04
25	Pyridine, 2-pentyl-	$C_{13}H_{13}N$	183.254	5.6498	0.95
26	Cyclononasiloxane, octadecamethyl-	$C_{18}H_{54}O_9Si_9$	667.368	10.71	0.94
27	1,2,3,4,5,6-Hexa-O-trimethelsilyl-myo-inositol	$C_{24}H_{60}O_6Si_6$	613.248	11.83	0.92
28	Decanedioic acid, dibutyl ester	$C_{18}H_{34}O_4$	314.466	12.95	0.89
29	3,5,5-Trimethyl-4-(3-((trimethylsilyl)oxy)butyl)cyclohex-2-enone	$C_{16}H_{30}O_2Si$	282.499	10.57	0.88
30	Niacin	$C_6H_5NO_2$	123.111	6.12	0.87
31	Galactopyranose, 5TMS derivative	$C_{21}H_{52}O_6Si_5$	541.066	17.97	0.84
32	γ-Sitosterol	$C_{29}H_{50}O$	414.718	19.41	0.81
33	Bohlmann k2631	$C_{15}H_{20}O_2$	232.323	11.92	0.71
34	2-Furoic acid, TMS derivative	$C_8H_{12}O_3Si$	184.266	4.95	0.70
35	Glucose, 5TMS derivative	$C_{21}H_{52}O_6Si_5$	541.066	12.25	0.68
36	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	354.619	14.95	0.66
37	Acetin, bis-1,3-trimethylsilyl ether	$C_{11}H_{26}O_4Si_2$	278.495	5.40	0.65
38	Azelaic acid	$C_9H_{16}O_4$	188.223	9.34	0.64
39	1H-Indole, 1-(trimethysilyl)-2,5-bis[(trimethylsilyl)oxy]-	$C_{17}H_{31}NO_2Si_3$	365.695	10.94	0.60
40	4-Hydroxybutanoic acid, 2TMS derivative	$C_{10}H_{24}O_3Si_2$	248.669	5.90	0.58
41	4-Hydroxy-2,2',4',6'-tetrachlorobiphenyl, trimethylsilyl ether	$C_{15}H_{14}C_{l4}OSi$	380.161	16.11	0.58
42	Octacosane	$C_{28}H_{58}$	394.772	16.28	0.57
43	N,N-Bis(2-hydroxyethyl)-p-toluidine	$C_{11}H_{17}NO_2$	195.262	14.38	0.56
44	.delta.-Tocopherol, TMS derivative	$C_{30}H_{54}O_2Si$	474.845	16.85	0.55
45	Hexacosane	$C_{26}H_{54}$	366.718	13.75	0.54
46	Hexanoic acid, TMS derivative	$C_9H_{20}O_2Si$	188.342	4.34	0.48
47	Pimelic acid, 2TMS derivative	$C_{13}H_{28}O_4Si_2$	304.533	9.09	0.43
48	Stigmastanol, TMS derivative	$C_{32}H_{60}OSi$	488.916	19.61	0.42
49	1,4-Bis(3-methoxy-4-((trimethylsilyl)oxy)phenyl)tetrahydro-1H,3H-furo[3,4-c]furan	$C_{26}H_{38}O_6Si_2$	502.754	19.33	0.39
50	Silanol, trimethyl-, benzoate	$C_{10}H_{14}O_2Si$	194.305	6.05	0.38
51	2-Deoxy-1,3,4,5-tetrakis-O-	$C_{17}H_{44}O_4Si_4$	424.875	9.15	0.38

	(trimethylsilyl)pentitol				
52	n-Tetracosanol-1	$C_{24}H_{50}O$	354.663	14.23	0.36
53	Xylitol, 5TMS derivative	$C_{20}H_{52}O_{5S}i_5$	512.056	10.07	0.35
54	(3R,4R)-2,5-dimethoxy-2,5-dimethyl-hexane-3,4-diol	$C_{10}H_{22}O_4$	206.282	7.91	0.34
55	Ferulic acid, methyl ester, O-TMS	$C_{14}H_{20}O_4Si$	280.395	11.65	0.32
56	5-Propyl-10,11-dihydro-5H-dibenzo[a,d]cyclohepten-5,10-imine hydrochloride	$C_{18}H_{19}N$	249.357	12.85	0.32
57	L-Valine, TMS derivative	$C_8H_{19}NO_2Si$	189.33	4.53	0.30
58	Levoglucosenone	$C_6H_6O_3$	126.111	4.87	0.30
59	Pentan-3-ol, trimethylsilyl ether	$C_8H_{20}OSi$	160.332	5.06	0.30
60	Benzeneacetic acid, trimethylsilyl ester	$C_{11}H_{16}O_2Si$	208.552	6.52	0.30
61	Benzaldehyde, 3-methoxy-4-[(trimethylsilyl)oxy]-, O-methyloxime	$C_{12}H_{19}NO_3Si$	253.373	9.47	0.30
62	7,12-Dithia-14-azadispiro[4.0.5.3]tetradeca-9,13-diene, 9,10-dimethyl-13-phenyl-	$C_{19}H_{23}NS_2$	329.52	15.58	0.26
63	Heptadecanoic acid, TMS derivative	$C_{23}H_{48}O_2Si$	384.72	12.79	0.26
64	Phloretic acid, 2TMS derivative	$C_{15}H_{26}O_3Si_2$	310.54	10.32	0.26
65	2'-Hydroxy-6'-methoxyacetophenone, TMS derivative	$C_{12}H_{18}O_3Si$	238.358	8.23	0.26
66	3-(4-Hydroxyphenyl)-1-propanol, 2TMS derivative	$C_{15}H_{28}O_2Si_2$	296.557	9.73	0.25
67	Olean-18-en-3-ol, O-TMS, (3.beta.)	$C_{33}H_{58}OSi$	498.911	19.52	0.25
68	2-Monooleoylglycerol trimethylsilyl ether	$C_{27}H_{56}O_4Si_2$	500.911	15.97	0.25
69	Phenol, 4-ethenyl-2,6-dimethoxy-	$C_{10}H_{12}O_3$	180.203	8.85	0.24
70	Pantothenic acid tritms	$C_{18}H_{41}NO_5Si_3$	435.783	11.97	0.23
71	Isoquinoline, 1-[(3,4-diethoxyphenyl)methyl]-6,7-diethoxy-	$C_{24}H_{29}NO_4$	395.499	13.36	0.22
72	Dodecanoic acid, trimethylsilyl ester	$C_{15}H_{32}O_2Si$	272.504	9.44	0.21
73	Pentanedioic acid, 3-methyl-3-[(trimethylsilyl)oxy]-, bis(trimethylsilyl) ester	$C_{15}H_{34}O_5Si_3$	378.687	9.146	0.20
74	Galactinol, nonakis(trimethylsilyl) ether	$C_{39}H_{94}O_{11}Si_9$	991.935	17.27	0.19
75	Salicylic acid	C7H6O3	138.122	6.60	0.19
76	Androst-4-ene-3,17-dione, 15-hydroxy-, (15.alpha.)-	$C_{19}H_{26}O_3$	302.414	14.55	0.19
77	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{32}O$	264.453	12.81	0.19
78	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	$C_{17}H_{24}O_3$	276.376	11.47	0.19
79	(+)-a-ar-curcumene	$C_{15}H_{22}$	202.341	8.18	0.18
80	Ethyl .alpha.-D-glucopyranoside, 4TMS derivative	$C_{20}H_{48}O_6Si_4$	496.938	13.49	0.15
81	Diethylene glycol, 2TMS derivative	$C_{10}H_{26}O_3Si_2$	250.485	5.99	0.15
82	2-O-Glycerol-.alpha.-d-galactopyranoside, hexa-TMS	$C_{27}H_{66}O_8Si_6$	687.327	13.99	0.15
83	5-O-Coumaroyl-D-quinic acid, 5TMS	$C_{31}H_{58}O_8Si_5$	699.222	17.32	0.15
84	Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326.565	13.86	0.14
85	Octahydro-1H-cyclopenta[b]pyridin-4-ol	$C_8H_{15}NO$	141.214	4.26	0.14
86	Acetic acid, 2-[(6-methoxy-4-methyl-2-quinolinyl)thio]-, hydrazide	$C_{13}H_{15}N_3O_2S$	277.342	11.28	0.13
87	(E)-methoxy-[2,3,4,5-tetrakis(trimethylsilyloxy)-1-(trimethylsilyloxymethyl)pentylidene]amine	$C_{22}H_{55}NO_6Si_5$	570.108	11.25	0.13
88	Phosphoric acid, bis(trimethylsilyl) 2,3-bis[(trimethylsilyl)oxy]propyl ester	$C_{15}H_{41}O_6PSi_4$	460.801	10.41	0.11
89	Propanetriol, 2-methyl-, tris-O-(trimethylsilyl)-	$C_{13}H_{34}O_3Si_3$	322.667	7.88	0.10
90	3-[(Trimethylsilyl)oxy]indene	$C_{12}H_{16}OSi$	204.344	7.51	0.09
91	L-Proline, 5-oxo-1-(trimethylsilyl)-, trimethylsilyl ester	$C_{11}H_{23}NO_3Si_2$	273.479	8.52	0.08

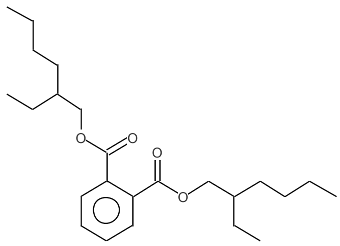
92	3-Vanilpropanol, bis(trimethylsilyl)-	$C_{16}H_{30}O_3Si_2$	326.583	10.75	0.08
93	1-Pentanol, 5-chloro-, acetate	$C_7H_{13}ClO_2$	164.629	4.35	0.07
94	Triethylene glycol, 2TMS derivative	$C_{12}H_{30}O_4Si_2$	294.538	8.30	0.07
95	2-O-(2-(4-hydroxyphenyl)-ethyl)-d- β-glucopyranose, 5TMS	$C_{29}H_{60}O_7Si_5$	661.217	16.31	0.07
96	Glycolic acid, 2TMS derivative	$C_8H_{20}O_3Si_2$	220.415	4.39	0.07
97	2,5-Dimethyl-4-hydroxy-3(2H)-furanone	$C_6H_8O_3$	128.127	4.30	0.07
98	Butanoic acid, 2-methyl-3-[(trimethylsilyl)oxy]-, trimethylsilyl ester	$C_{11}H_{26}O_3Si_2$	262.496	5.57	0.07
99	Ricinoleic acid, 2TMS derivative	$C_{24}H_{50}O_3Si_2$	442.831	14.82	0.07
100	4-Coumaric acid, 2TMS derivative	$C_{15}H_{24}O_3Si_2$	308.524	11.57	0.06
101	Hexadecanoic acid, 4-[(trimethylsilyl)oxy]butyl ester	$C_{23}H_{48}O_3Si$	400.719	15.88	0.06
102	cis-13-Octadecenoic acid	$C_{18}H_{34}O_2$	282.468	12.78	0.06
103	Methanone, (2-methoxyphenyl)(5,6,7,8-tetrahydro-1,4-dimethoxy-2-naphthalenyl)-	$C_{20}H_{22}O_4$	326.392	15.43	0.05

Table 2: Possible antibacterial and antifungal compounds in methanolic inflorescence extract of *Carthamus oxycantha*.

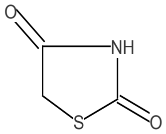
Compound No.	Names of compounds	Property	Reference
5	9-Octadecenoic acid, (E)-, TMS derivative	Antibacterial	(Karthikeyan *et al.*, 2014)
6	Bis(2-ethylhexyl) phthalate	Antimicrobial	(Habib and Karim, 2009)
19	2,4-Thiazolidinedione	Antimicrobial	(Alagawadi and Alegaon, 2011)
32	γ-Sitosterol	Antimicrobial	Karthikeyan et al. (2014) (Canli *et al.*, 2017)



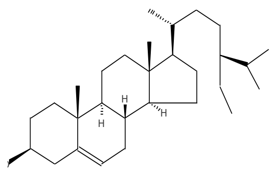
5. 9-Octadecenoic acid, (E)-, TMS derivative



6. Bis(2-ethylhexyl) phthalate



19. 2,4-Thiazolidinedione



32. γ-Sitosterol

Fig. 1: Structures of antibacterial and/or antifungal compounds identified in methanolic inflorescence extracts of *Carthamus oxycantha*.

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